Embedded Software

CS 145/145L

Caio Batista de Melo
Announcements (2022-06-02)

● Homework 5 is due tomorrow
● Project 5 is due end of finals week
  ○ But no labs next week, use edstem if you need help
● Please submit your course evaluations
  ○ Extra credit on P5 demo
  ○ Help improve this and future courses
  ○ [https://evaluations.eee.uci.edu](https://evaluations.eee.uci.edu)
  ○ Closes on 2022-06-06 at 7:50am
Agenda

● Pattern Recognition
  ○ Feature Extraction
  ○ Recognition

● Field Programmable Gate Arrays (FPGAs)
  ○ What?
  ○ Why?

● Life after CS145
Pattern Recognition
Pattern Recognition Framework

Occupancy Room Detector

This is DSP!
Pattern Recognition Framework

Let's take a look at these two new boxes

Generic Framework
Feature Extraction

Generating meaningful data from signal

Examples:
- Speed or distance for a vehicle
- Number of voices for a smart speaker
- Empty spot in a parking lot
- Screen attention
Pattern Recognition

Figuring out what the features mean

Examples:

- Speed or distance for a vehicle
  - Highway or local street? Safe braking distance?
- Number of voices for a smart speaker
  - User or TV? Which user? Speaking to me?
- Empty spot in a parking lot
  - Available or not
- Screen attention
  - User reading something, keep screen on
Pattern Recognition Example

Pattern Recognition Example

https://dl.acm.org/doi/abs/10.1145/3358175
FPGAs
Hardware Accelerators

- Some problems are hard…
- Like division!
- Integer division has a latency of 9–17 cycles for 16-bits and 9–25 for 32-bits
- Integer multiplication takes only 3 cycles

https://dl.acm.org/doi/abs/10.1145/3287624.3287668
### Custom Hardware (e.g., Accelerators) Problem

Expensive to tape out

<table>
<thead>
<tr>
<th>MPW Service Provider</th>
<th>INCLUDES ACCESS TO EDA TOOLS + AUTOMATED DESIGN FLOW</th>
<th>INCLUDES FULL CHIP REFERENCE DESIGN</th>
<th>INCLUDES SILICON FABRICATION</th>
<th>INCLUDES PACKAGING AND EVALUATION BOARD</th>
<th>INCLUDES SOFTWARE / TEST</th>
<th>DESIGN SUPPORT / EXPERTISE NEEDED</th>
<th>TOTAL DEVELOPMENT COST</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>✗</td>
<td>✗</td>
<td>✔</td>
<td>✗</td>
<td>✗</td>
<td>No support / high-level of expertise needed</td>
<td>$$$</td>
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<tr>
<td>Contract a Design Services Provider</td>
<td>&lt; ------------------------&gt; Depends on service provider &lt; ------------------------&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Experience managing chip development projects</td>
<td>$$$$$</td>
</tr>
<tr>
<td>Hire an In-house Design Team</td>
<td>&lt; ------------------------&gt; Additional cost required &lt; ------------------------&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>No support / high-level of expertise needed</td>
<td>$$$</td>
</tr>
<tr>
<td>Create your Chip using chipIgnite</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>Large design community and library of example projects</td>
<td>$</td>
</tr>
</tbody>
</table>

[https://efabless.com/](https://efabless.com/)
Really expensive to tape out

Chip Creation Made Simple

chipIgnite provides you with a pre-built chip for integrating your custom design and an automated open-source design flow making it easy and affordable.

Only $9750 per project

https://efabless.com/
Field Programmable Gate Arrays (FPGAs)

- FPGAs let you define your circuit
- Allows for rapid prototyping
- Adds an overhead due to flexibility
- Can be much cheaper (< $100)
- Debug before taping out a chip

https://www.researchgate.net/publication/290929451
FPGA Example

https://github.com/lowRISC/ariane
FPGA Example

Future
ATmega32 ideas:

- https://circuitdigest.com/atmega32-projects
- https://github.com/topics/atmega32

Can also look into other cheap options (e.g., Arduino, Raspberry Pi).
Other UCI Courses

- **CS 151: Digital Logic Design**
  - Opens up other classes (152, 153, 154)

- **CS 147: Internet of Things (IoT) Software and Systems**
  - Similarly structured to 145, projects with arduino boards

- **CS 111: Digital Image Processing**
  - “Introduction to the fundamental concepts of digital signal and image processing…”

- **CS 143A: Principles of Operating Systems**
  - Opens up other classes (131, 133, 143B, 146*)

- **CS 132: Computer Networks**
  - Opens up other classes (133, 134)
Grad School?

Graduate Programs in Embedded Systems (ranked by distance):

- [https://mecps.uci.edu/](https://mecps.uci.edu/)
- [https://jacobsschool.ucsd.edu/mas/wes](https://jacobsschool.ucsd.edu/mas/wes)
- [https://www.colorado.edu/ecee/academics/graduate-programs/professional-master-s/embedded-systems-engineering-and-internet-things](https://www.colorado.edu/ecee/academics/graduate-programs/professional-master-s/embedded-systems-engineering-and-internet-things)
- [https://www.cis.upenn.edu/graduate/program-offerings/mse-in-embedded-systems/](https://www.cis.upenn.edu/graduate/program-offerings/mse-in-embedded-systems/)

Not an exhaustive list! Can also look into CS/CSE/EECS programs.

You can also likely go directly into industry!
Enjoy your summer :)

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